Swinging the Pendulum-Acid-Base Chemistry for Herbalists— Dr. Kenneth Proefrock

We discuss the natural origins of acids and bases, historical methods of extraction, isolation and concentration of such strongly acting chemical agents. We will include discussion of the impact of pH on alkaloid expression in botanical extraction practices, nixtamalization, bicarb vs vinegars, acetracts and spagyric tinctures, culinary ash, and some potentially interesting insight into the manufacture of plant dyes and color changes with shifting pH.

Consider a molecule of water H₂O, sitting at room temperature, in a glass. At any given moment that molecule is disassociating into two components--H⁺ and OH⁻...if that is happening exactly half the time and the water is pure, we can assume the solution has a neutral pH, around 7, we might say that there is as much acid potential as there is alkaline potential in that solution. If that pH is lower than seven, the water is acidic and if over seven, it is basic or alkaline. If none of that makes sense to you, that is ok. By the end of this discussion, it will make a lot more sense. This is the world of duality in chemistry, acid and alkaline. The original concept of acidity comes to us from the ancient Greeks who used the term oxein for "sour-tasting" substances, which mutated into the Latin word acetum (associated with vinegar) which became anglicized to today's "acid". Acidic substances not only taste sour but also corrode metals and dissolve minerals into solution. In contrast, bases (alkaline agents) tend to taste bitter or metallic and have the ability to counteract acids, sometimes with violent effervescence-and so, are associated with the acids in their chemical characterization. The term "alkaline" is derived from a 10th century Arabic word *al-galī* which meant "the burnt ashes of saltwort (a common name that applies to plants of the Salsola, Soda (Seidlitzia), and Salicornia families) which grow in alkaline soils, and whose ashes are good sources of alkali material (KOH, NaOH). The idea that acidity/alkalinity was associated with the presence/absence of hydrogen ions was not proposed until the mid-19th century by the German chemist Justus von Liebig (1803–1873) and in the 1890's the Swedish chemist, Arrhenius (1859-1927), went so far as to provide a definition of acids as "substances delivering hydrogen cations (H⁺) to the solution" and bases as "substances delivering hydroxyl (OH⁻) anions to the solution". He also proposed that the mechanism by which acids and bases interacted to neutralize one another was by forming water and the appropriate salt, $(H^+ + OH^- \le)$ H₂O) which is still accepted dogma today. The class of bases has been expanded to include any substance capable of binding protons (H⁺), and as an example (OH⁻), and the definition of acid can include any substance that releases a proton (H⁺). These definitions, relying on protons and hydroxyl ions as they do, generally relate to reactions in water solutions and we should remember that we are not dealing with absolutes here as much as relative values in a continuum of change--there is a constant flux between intact H₂O molecules and the disassociated ions.

 H^+ and OH^- , variables like temperature and atmospheric pressure also have a bearing on this flux, which makes proving any of it a bit of a moving target.

We cannot know how significant a phenomenon is until we can measure it...and the earliest laboratory for exploring the universe of acids and bases was the textile dye industry. Early experiments revealed that commonly used dyeing agents became different shades and even different colors when a vinegar was added or when urine or the ashes from a particular burned plant were added to the dyeing solution. In ways that only human expression in the form of fashion can drive industry and understanding, a sophisticated awareness of the acid-base spectrum became established, people want vibrant and unique colors, subtle adjustments in the amount of an acid or a base could accomplish such color change. One of those sources of the purple dye, orcein, also called orchil, was any of several types of lichen known as "orchella weeds", found throughout the world, Roccella tinctoria is a commercially important example. These lichens produce orchill dye precursors that are traditionally soaked in urine (or other sources of ammonia) and water while under constant stirring to encourage oxygenation and, ultimately, fermentation, to develop a deep purple color. If the conversion is carried out in the presence of potassium carbonate, calcium hydroxide, and calcium sulfate (in the form of potash, lime, and gypsum in traditional dye-making methods), the result is litmus, a more complex molecule whose manufacture was described by Cocq in 1812. Litmus is an orchill dye whose color change is calibrated to different pH values around the range of 4.5-8.3. Litmus is red under acidic conditions (less than pH of 4.5) and blue under alkaline conditions (greater than pH 8.3), purple indicates a neutral pH (between 4.5 and 8.3). The word "litmus" comes from an Old Norse word for "moss used for dyeing" and as early as 1300, the Spanish physician Arnaldus de Villa Nova reported using litmus to study acids and bases. Eventually, filter paper embedded with dried litmus extracts became a common laboratory method of evaluating acids and bases, the original "litmus test". In his 1909 paper in Biochemische Zeitschrift, Danish chemist Søren Sørenson proposed a new color change assay for acidity based on electro-chemical principles and the use of a glass electrode. In this paper, he defined the concept of acidity as the "negative logarithm of the hydrogen ion concentration in a solution", a number he called the 'potential of hydrogen' or pH. He was one of the first to define pH and to attempt to use electrostatic methods of measurement which involved a hydrogen ion electrode in combination with a calomel reference electrode. The usefulness of the pH concept was largely ignored by chemistry and biology until Leonor Michaelis (of Michaelis/Menten enzyme kinetics fame) published a monograph establishing the critical importance of pH to enzyme activity and the relative importance of measuring pH to other arenas of analytical research. The modern measurement of pH was revolutionized in 1930 with the development of a hydrogen permeable glass electrode, which, in 1934, was employed by Arnold O. Beckman in his "acidimeter", an invention he created for the California Fruit Growers Association. The citrus growers needed a portable way of monitoring fruit acidity during the production of pectin and citric acid-sulfur dioxide was commonly used as a preservative and interfered with other methods of testing. Beckman designed a sensitive and sturdy instrument that used a pair of vacuum-tube signal amplifiers and gas permeable glass electrodes to measure the pH of any solution. Variations on Beckman's design are still used in laboratories today all over the world, it is a consistent and reliable measuring device. The pH scale runs from 0-14 and is set up in an inverse manner such that the acidic solutions are on the lower end of the scale-0.5-1.5 and the extreme alkaline solutions are in the 13.0-14.0 range, neutral pH is 7.0.

There are strong acids and weak acids as there are stronger bases and weaker bases, the strength of these compounds is determined by their degree of disassociation, the stronger the acid or the base, the more completely the H⁺ and/or the OH⁻ is separated from the parent molecule and the more electrically conductive the solution becomes. The stronger the acid or base, the less likely there will be a reversible equilibrium--that is the tendency to reform the parent compound once the respective ions have disassociated; weaker acids and bases will move between ionized and non-ionized molecular forms with a proportionate ease, whereas, a strong acid or base, once ionized tends to not reform the original compound. Hydrochloric acid (HCl) is the strongest naturally occurring acid-and is part of the digestive process for many animals. Lime, calcium hydroxide (Ca(OH)₂, is the strongest naturally occurring base and is formed from heating limestone (CaO) often through volcanic activity or intentional cooking. There are only a handful of strong acids and strong bases and there is an almost infinite number of weak acids and bases, they represent critical components in the electron transport chain and the oxidation-reduction reactions that biological systems use to generate energy and stay alive, they also represent a vast buffering system for the constant adjustment of local pH. In mammals, a part of that buffering system involves the presence of large negatively charged proteins like albumin being widely present and available to absorb a certain amount of acid and alkali material in order to preserve a more moderate pH range.

When applying aqueous solutions to living systems, the pH of that solution is a therapeutically useful parameter to consider. Qualitatively, the most important pH buffering system within the body is the bicarbonate buffer system, which involves the lungs and the kidneys. This system is unique in that it remains in equilibrium with atmospheric air through the respiratory system; thus, it is an open system with a much greater capacity to buffer body fluids than any closed system would manage. The pH buffering impact of the bicarbonate system is based on the equilibration of CO₂ with carbonic acid, the activity of the enzyme carbonic anhydrase, bicarbonate ion and hydrogen ion concentrations, respiratory rate, and hydrogen ions into the urine.

$CO_2 + H_2O \iff H_2CO_3 \iff H^+ + HCO_3^-$

In our reversible chemical process, increasing the reactants on the left tends to push the reaction to the right, i.e., an accumulation of water and CO₂ in the tissues of the lungs tends to increase tissue production of carbonic acid and, ultimately, bicarbonate and protons. This is why one's breathing rate becomes a primary method of managing internal pH and why breathing into a paper bag when one is hyperventilating can be helpful; the re-breathing of the CO2 tends to make the system, initially, more alkaline, which tends to have a relaxing effect on the nervous system. Purposely increasing the bicarbonate levels in tissues by applying it in an aqueous solution leaves the tissues more alkaline and

increases CO₂ and water movement out of the body through the lungs and kidneys, often a very beneficial effect for patients with restricted airways that are not as able to perform that role. While the lung and changing respiratory rates plays a relatively critical role in managing pH, the kidney plays a similar and more long-term role by actively excreting acid, as H⁺ or base, as HCO₃⁻ into the urine, rendering the urine either acidic or alkaline. An essential consideration in this process is the role of adequate amounts of water in maintaining appropriate pH levels; as the old chemistry adage reminds us, "where the water goes, so go the electrolytes." Sufficient potassium in the system is a crucial factor in how the body moves acids into the intracellular protein buffer system. Potassium (K^{+}) has a relatively alkalinizing effect on physiology through intracellular K⁺ being chemically exhanged for acidic H⁺ in the plasma proteins. As the H⁺ concentration increases, the intracellular protein buffering system can have access to and neutralize the plasma H⁺ by exchanging the similarly charged but not acidic (not a proton) K⁺ which results in transient increases in plasma potassium levels with the more long-term diminishment of the intracellular potassium reservoir, leading ultimately to a potassium deficiency. The reverse of this process is how the body deals effectively with metabolic alkalosis; that is, as the plasma levels of H⁺ decline; potassium in the plasma is exchanged for intracellular hydrogen ions to compensate. Another point worth stating is that bronchodilators like Albuterol sulfate and levalbuterol, often used chronically by asthma and COPD patients, have a known side effect of reducing the body's intracellular potassium stores, which is associated with aberrations in heart rate.

Mucus is a large protein/polysaccharide structure involved in maintaining membrane health that can be dramatically affected by shifting both osmolarity and pH. It is a conglomeration of the secreted protein mucin and the numerous saccharides that glycosylate it, creating branching molecular structures that serve to establish a degree of slimy-ness to crunchy-ness in the matrix of the mucus, aka snot vs. boogers. Some of the most critical of these saccharides are the family of sialic acids and, also within this family, the compound neuraminic acid. Sialic acids contribute significantly to the viscosity of mucus; the more acidic the environment, the higher the viscosity or thickness of the mucus; alternately, the more alkaline the internal environment, the thinner the mucus. The metabolically acidic nature of the infectious process creates a thickening of the mucoid secretions, making them significantly more "sticky," a measure which helps impede further progression of the infection but also more difficult expectoration. The relatively acidic environment in the airways and other mucus membranes contributes to tissue constriction through a neural reflex (acidity creates 'tension' in the tissues), inhibition of histamine breakdown, and contributes to tissue irritation. One of the reasons the Influenza family of viruses is so virulent is that it has evolved a neuraminidase enzyme that allows the viral particles to cleave through the thickening and protective neuraminic acid component of the mucus and infect adjacent tissues to the primary site of infection. Neutralizing the acidity of mucus makes it a looser, thinner material, facilitating liquefaction of the more problematic secretions, promoting relaxation and improvement of blood flow into and out of the affected tissues, and inactivating histamines. Applying relatively alkaline solutions to the affected tissues represents a

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decided advantage in treating patients with many congestive conditions of the mucus membranes. I find that using potassium bicarbonate, where reasonable, as a buffer to bring the pH of a topical solution into a slightly alkaline realm adds even more significantly to the therapeutic potential.

Acid				Base		
Strength of Acid	Ка	Name	Formula	Formula	Name	Strength of Base
Strongest	Large	Perchloric acid	HClO₄	CIO ₄ -	Perchlorate ion	Weakest
	3.2×10 ⁹	Hydroiodic acid		I-	Iodide	
	1.0×10 ⁹	Hydrobromic acid	HBr	Br-	Bromide	
	1.3×10 ⁶	Hydrochloric acid	HCI	CI-	Chloride	
	1.0×10 ³	Sulfuric acid	H_2SO_4	HSO ₄ -	Hydrogen sulfate ion	
	2.4×10 ¹	Nitric acid	HNO ₃	NO ₃ -	Nitrate ion	
		Hydronium ion	H ₃ O+	H₂O	Water	
	5.4×10-2	Oxalic acid	$HO_2C_2O_2H$	HO ₂ C ₂ O ₂ -	Hydrogen oxalate ion	
	1.3×10-2	Sulfurous acid	H_2SO_3	HSO ₃ -	Hydrogen sulfite ion	
	1.0×10-2	Hydrogen sulfate ion	HSO₄ -	SO ₄ ² -	Sulfate ion	
	7.1×10-3	Phosphoric acid	H₃PO₄	H ₂ PO ₄ -	Dihydrogen phosphate ion	
	7.2×10-4	Nitrous acid	HNO ₂	NO ₂ -	Nitrite ion	
	6.6×10-4	Hydrofluoric acid	HF	F-	Fluoride ion	
	1.8×10-4	Methanoic acid	HCO₂H	HCO ₂ -	Methanoate ion	
	6.3×10 ⁻⁵	Benzoic acid	C ₆ H₅COOH	C ₆ H₅COO-	Benzoate ion	
Medium	5.4×10 ⁻⁵	Hydrogen oxalate ion	HO ₂ C ₂ O ₂ -	O ₂ C ₂ O ₂ ² -	Oxalate ion	Medium
	1.8×10-5	Ethanoic acid	CH₃COOH	CH₃COO	Ethanoate (acetate) ion	
	4.4×10 ⁻⁷	Carbonic acid	$H_2 CO_3$	HCO ₃ -	Hydrogen carbonate ion	
	1.1×10-7	Hydrosulfuric acid	H₂S	HS-	Hydrogen sulfide ion	
	6.3×10 ⁻⁸	Dihydrogen phosphate ion	H ₂ PO ₄ -	HPO ₄ ² -	Hydrogen phosphate ion	
	6.2×10 ⁻⁸	Hydrogen sulfite ion	HS-	SO3 2-	Sulfite ion	
	2.9×10 ⁻⁸	Hypochlorous acid	HCIO	CIO-	Hypochlorite ion	
	6.2×10 ⁻¹⁰	Hydrocyanic acid	HCN	CN-	Cyanide ion	
	5.8×10 ⁻¹⁰	Ammonium ion	NH ₄ +	NH ₃	Ammonia	
	5.8×10 ⁻¹⁰	Boric acid	H ₃ BO ₃	H ₂ BO ³⁻	Dihydrogen borate	
	4.7×10 ⁻¹¹	Hydrogen carbonate ion	HCO ₃ -	CO32-	Carbonate ion	
	4.2×10 ⁻¹³	Hydrogen phosphate ion	HPO ₄ ²⁻	PO ₄ ³⁻	Phosphate ion	
	1.8×10 ⁻¹³	Dihydrogen borate ion	H ₂ BO3-	HBO ₃ ²⁻	Hydrogen borate ion	
	1.3×10 ⁻¹³	Hydrogen sulfide ion	HS-	S ²⁻	Sulfide ion	
	1.6×10 ⁻¹⁴	Hydrogen borate ion	HBO ₃ ²⁻	BO ₃ ³⁻	Borate ion	
Weakest		water	H ₂ O	OH-	Hydroxide	Strongest

Osmolarity is another variable worth consideration when we are talking about therapeutic solutions, it is the density of the solution based on the number of moles of dissolved particles per liter of solution. The root of the word is osmosis which describes the movement of a solvent across a semipermeable membrane toward a higher concentration of solute (lower concentration of solvent). The solvent is typically water in biological systems, but osmosis can occur in other liquids, supercritical liquids, and even gases. When a living cell is submerged in pure water (a hypo-osmolar solution), the water molecules pass through the cell membrane from an area of low solute concentration (outside the cell) to high solute concentration (inside the cell), if the material inside the cell is unable to leave the compartment, the cell swells. If the cell is submerged in saltwater (a hyper-osmolar solution), water molecules move out of the cell into the more solute dense exterior environment, and the cell shrinks. When the solvent has a similar amount of solute on both sides (iso-osmolar), water molecules pass in each direction at precisely the same rate. There is no net flow of water through the membrane. Osmolarity represents a way of determining the relative concentration of osmotically relevant particles in any solution. Those solutions considered iso-osmolar to human physiology have roughly the same amount of dissolved solute as the bloodstream-defined as roughly, 280-310 milliosmoles/ml. Solutions that are relatively hypo-osmolar, containing less than 280 mOsm/ml, are less dense, more 'watery,' and tend to leave behind more of a water portion in the tissues; they can be relatively hydrating to body tissues. Solutions that are relatively hyper-osmolar, greater than 310 mOsm/ml, tend to pull more fluid from the tissues and leave them relatively more dehydrated, reducing tissue swelling. These are helpful therapeutic qualities for topical solutions; for patients who have chronically dry eyes, a slightly hypo-osmolar solution can be a phenomenal way to hydrate the tissues while washing away irritating debris. A hyperosmolar solution can be helpful in conditions of edema in the throat, sinuses, eyes, or skin by drawing fluid out of the interstitium, which is the rationale behind gargling with salt water for a sore throat.

An iso-osmolar preparation commonly used in medicine is "normal saline," a mixture of 0.9% sodium chloride in water; it is the most commonly employed intravenous fluid in the treatment of dehydration. 0.9 % means that there is 9 mg of salt in every ml of water or 9 gms of salt in a liter of water. There is a simple calculation to determine the osmolarity of a solution based on how many osmotically relevant particles are present in a 1 Molar solution (1 Mole of material per liter). NaCl has two ionizing particles, Na⁺ and Cl⁻, which means we will have to account for both ions in our final calculation. A 1M solution would require 58.4 gms of NaCl (Na⁺=23 gms/mole, Cl⁻=35.45 gms/mole) in 1 liter of solution, also represented as 5.84%. Normal saline, at 9 gms/liter divided by the Molar weight of NaCl (9 gms/58.4 gms), yields 0.154 Osm/L for each osmotically relevant ion. Adjusting to account for both ions, we get an osmolarity of 0.308 Osmoles/Liter...or 308 milliosmoles per liter. Therefore, normal saline is an iso-osmolar solution because it falls within the range of 280-310 mOsm/L.

This can be tricky for some; at the risk of belaboring the point, consider a 5% solution of dextrose (D5W), a commonly used intravenous preparation. There is only one

osmotically relevant particle, and that is dextrose. Dextrose has a molecular weight of 180.156; however, it exists as a monohydrate, so we have to add the molecular weight of one water molecule, which is 18. A 1M solution would consist of 198 grams of dextrose monohydrate in 1 liter of water; a 5% solution has 50 grams in the liter of water. Using our previous ratio, 50/198=0.252 osmoles/liter or 252 milliosmoles/liter...this is a physiologically hypo-osmolar solution. In another example, MgCl₂ is a commonly used solution that disassociates into three osmotically relevant particles, Mg⁺, Cl⁻, and Cl^{-,} and its molecular weight is 95.2 gms/mole. It is typically made as a 10% solution, 100 mg/ml. A liter of MgCl₂ would require adding 100 gms to a liter of water, and a 1M solution would require 95.2 gms to be added to a liter of water. Our relevant Molar ratio is 100/95.2 and yields 1.05 osmoles/liter for each osmotically relevant ion and a total of 3.15 osmoles/liter (3,150 mOsm/L) when you add the values of each of the three ions together, a hyperosmotic solution. In a final example, magnesium sulfate exists as magnesium sulfate heptahydrate, commonly called 'Epsom salt,' after a bitter saline spring in Epsom, England. It is generally made as a 50% solution, 500 mg/ml. It has a molecular weight of 246.9 (Mg=24.03, S=32.06, O=16; MgSO₄=120.09 + 7 H₂O (7*18)=246.9) and has two osmotically relevant particles, Mg⁺ and SO₄⁻; a 1M solution would require 246.9 gms in 1 liter of water. Our 50% solution is 500 gms/liter; dividing that concentration by our Molar weight of 246.9 gms yields 2.028 Moles/liter, multiplied by the number of active ions, 2, gives us 4.06 osmoles/liter or 4,060 milliosmoles/l, an even more hyperosmotic solution than the previous example.

A simplified formula for calculating osmolarity is as follows:

milliosmoles per Liter = mass in gms/molecular weight (g/ml) multiplied by # of relevant ions multiplied by 1000.

Using our 0.9% NaCl example...9gms/58.4 gms x 2 x 1000 = 308.21

Using 50% MgSO4: 500gms/246 gms x 2 x 1000 = 4060 mosm/L (It is more useful to relate such solutions as mOsm/ml as we generally use ml doses of such strong additives, which is 4.06 mOsm/ml).

Using 1,4 beta-hydroxy-propyl-cyclodextrin--molecular formula: $C_{63}H_{112}O_{42}$ divided by 1541.5 g/mol gms--0.292 or 292 mOsm/ml, which yields an iso-discussion.

Oxidative damage is implicated in most disease processes, and it is becoming more and more common knowledge that anti-oxidants have great value in preventing and treating some of the major medical conditions of the modern world. The processes of oxidation and reduction are essential to the production of energy in our bodies, the ability to protect ourselves from the free radical fallout of these processes is what makes the difference between "burning out and fading away", to paraphrase Neil Young. Essentially, the processes of oxidation and reduction describe the movement of electrons between molecules. I learned a mnemonic in a college chemistry course that still serves me to this day. "LEO says GER"--Loss of Electrons is Oxidation, Gain of Electrons is

Reduction, that is, when a molecule loses an electron, it is in a relatively more oxidized state, its relative charge is +1, and when a molecule gains an electron, it is in a relatively more reduced state, its relative charge is -1. Consider a structure that could sequester +1's on one side and -1's on the other side of a membrane, that would be a battery. It is exactly this movement of charge across a membrane that generates the energy that powers a cell. The charge might be H⁺ ions on one side and OH⁻ on the other side, and the membrane has a mechanism, like an electrical trigger, that allows it to immediately open up channels that allow the ions to flow through and release their energy. The flow of electrical current through living tissues is hard on the tissue, acids and bases are hard on tissues, our systems have developed methods to use other charged molecules to generate electrical activity, like Na⁺, K⁺, Ca⁺, Mg⁺, Cl⁻, that are not as reactive and abrasive to living tissues. The specialized membranes that are involved in electron transport have evolved a family of waxes, known as ubiquinones, CoQ10 is an example, that impart an exceptional antioxidant effect, essentially containing the free radical electron "bullets" in its waxy molecular structure. The ability of any compound to act as an effective antioxidant is dependent on its ability to act as an electron "sink," that is, how well it can give and take electrons without being compromised in the process. The molecular architecture of those compounds that have proven themselves good anti-oxidants is typically rather elaborate and self-supporting. One of the great deficiencies in the magic bullet theory of therapeutics, where modern science tries to specify the "active constituent" of a plant substance and then purify and concentrate that substance to increase its effectiveness, is that the complementary architectural chemical cohorts are lost through refinement. Vitamin C is considered the penultimate water soluble anti-oxidant, yet more than 250 mg/day of pure vitamin C tends to become unstable under the oxidative load of modern life and as it is unable to give and take electrons, it breaks down and actually allows more oxidative damage than if it weren't present in the first place. Beta-carotene and Vitamin E are fat soluble anti-oxidants and have the exact same issues when they are administered in purified forms, this is one of the reasons why modern medicine is now second guessing the recommendation of these agents for patients with heart disease and smokers. When we consume these items as plant constituents or as complexes like mixed carotenoids, mixed tocopherols or vitamin C with flavonoids, they are significantly better at quenching free radical electrons without sacrificing themselves in the process. Antioxidants with redundant and self-supportive molecular architecture help neutralize free radicals, especially oxygen molecules lacking electrons. These free radicals, which are produced through normal metabolism and detoxification processes, scavenge their missing electrons from other molecules, and in the course of doing so may cause damage to important cell components such as fats, proteins, or DNA. The best protection against oxidative damage is a diet rich in color, full of flavonoids and anthocyanidins. The flavonoid family of polyphenols is one of the largest with over 4000 members; they act as anti-oxidant pigments and are responsible for the yellows, reds, blues and purples that color the natural world. The entire family of flavonoids have been shown to have antibacterial, anti-inflammatory, anti-allergic, anti-mutagenic, anti-viral, anti-neoplastic, antithrombotic and vasodilatory activity. The potent antioxidant activity of flavonoids and

their ability to scavenge hydroxyl radicals, superoxide anions, and lipid peroxy radicals, are among the most important of their functions; this activity is also what allows flavonoids to accomplish many of the aforementioned actions in the body.

One particular food source that has been a crucial part of the history of the cultures of meso-america and the desert southwest is maize, corn, Zea mays. In fact, corn is part of the biological and cultural heritage of several Latin American countries, including Mexico, with 59 different varieties, and Peru with 55 different varieties. Phytochemicals from corn have received less attention than those of fruits, vegetables and other grains even though the consumption of corn has been linked to the reduced risk of chronic diseases including cardiovascular disease, type 2 diabetes, obesity, some cancers and with the improvement of digestive tract health¹. Maize grows in a myriad of different shapes and color shades, such as blue, black, cherry, purple and red, colors from pigments related to phenolic, flavonoid, carotenoid, and terpene compounds, including anthocyanidins, in one or more of the kernel structures: pericarp, aleurone and/or endosperm. In Central America, the people developed a process called nixtamalization by the Aztecs (from the Náhuatl word nextli, "ashes" and tamalli, "cooked corn dough") developed for the preparation of maize which involves cooking and steeping maize in a lime (CaO and CaOH) solution (pH > 11) which softens the pericarp, hydrates the endosperm, partially solubilizes proteins and cell walls, facilitates starch swelling, and gelatinization. This process removes mycotoxins like fumonosins and bacterial contaminants in stored foods. Some 50%-80% of the niacin in maize occurs in a bound form as niacytin or niacinogen, which is biologically unavailable and renders the maize deficient in niacin until it is nixtamalized². The process also enhances the color, the flavor, and the texture of the masa and makes it a better source of calcium and iron.

The best raw materials make the best finished product and so whole, sound, mature kernels of maize with a high proportion of hard to soft endosperm are preferred and yield more masa and tortillas after nixtamalization. During the cooking and steeping of the nixtamal, the pericarp is converted into gums and some insoluble materials that bind water and improve the texture of tortillas. The maize must be cooked uniformly to provide adequate hydration and partial solubilization so that grinding produces a nonsticky masa that holds itself together and can be formed and baked into a desirable tortilla. Table tortillas are excellent when fresh but often become hard after several hours, alkaline tortillas retain softness and flexibility longer than regular tortillas because starch retrogradation is inhibited by the negative charges on the starch chains at pH > 9. Many commercial tortillas are acidified (pH 5.0-5.5) to activate preservatives, but starch retrogradation and staling are not inhibited at this pH. The process of nixtamalization begins with whole maize cooked in excess water containing 0.5%–2.0% of hydrated lime (CaOH)--that is, 5-20 grams per kilo of corn, at 83-100°C for 50-60 min, then cooled to 68°C and allowed to steep for 8–24 h. During this process the endosperm and germ are softened, the starch is partially gelatinized, and the alkali solubilizes cell walls leading to a weakened pericarp that is easier to remove. The nixtamal made by the traditional process is washed to remove loose pericarp and excess lime and is then immediately stone-ground to produce masa. The wet-ground product that is obtained as a dough

contains pieces of endosperm, aleurone, germ, pericarp, free starch granules, free lipids and dissolved solids that form a 'glue-like' material that holds together the masa structure. There is no gluten in the masa dough; cohesion of the mass is due to the surface tension of the water and is most successful when the particle size of the material is fine, and the amount of water contained is just enough to fill the spaces between the particles. The masa is flattened, shaped and baked on a griddle for 39s at 280°C to make tortillas. Not only does nixtamalization alter the taste of maize, chemically change the kernels making several otherwise unattainable essential amino acids and B vitamins more digestible, nixtamalization makes maize a food you can safely obtain 40% or more of your daily calories from and still live a happy, healthy life. Non-nixtamalized maize is not nutritionally complete, and a person receiving more than 40% of their calories from "raw" maize (that isn't also accompanied by a complementary protein like beans) would suffer from chronic malnutrition. "Corn sickness" was a serious epidemic in many parts of the Old World after maize was adopted and incorporated into peasant diets, and was even an issue in the American South during the Great Depression when Euro-Americans and Americans alike, whose culinary knowledge of maize derived from the Old World, turned to maize as a dietary staple, ignorant of the Aztecan magic that made it a better food.

Intentional use of fire is one of those things that distinguishes humans from the other animals, the production of warmth and for the conversion of materials from one form to another (clay to pottery, wood to ashes). Even the ashes left over from the fire turn out to have useful properties, ash mixed with fat creates soap, which the Egyptians figured out as a medical treatment for crocodile bites in 3000 BCE. Such a substance was also useful for other types of cleaning, even cooking and for medicine. The major components of wood ashes depend on the wood being burned; they are generally potassium carbonate (potash) and sodium carbonate (soda ash). From a chemical standpoint these two compounds are very similar and had been indistinguishable from one another until the 19th century. The elements in the first column of the Periodic Table, including sodium and potassium, are called the *alkali* metals, alkali substances tend to have a bitter taste and a slightly soapy feel when rubbed in the fingers. The isolation of alkali is the precursor to making true soap and the isolation of potash was that original breakthrough (although everything that follows here is likewise true for sodium carbonate), potassium carbonate becomes potassium and carbonate as it ionizes in water: $K_2CO_3(s) \longrightarrow 2 K^+(aq) + CO_3^{2-}(aq)$

Once in solution, the potassium ions are unreactive. Such an ion is referred to as a *spectator* ion because it does not participate in further chemical reactions. The carbonate ion, on the other hand, acts as a base in aqueous solution, that is, it absorbs hydrogen ions wherever it finds them. The reaction we write depends on whether the solution was acidic or basic to begin with. In acidic solution we can write: $CO_3^{2-}(aq) + H^+(aq) < ----> HCO_3^{-}(aq)$

while in alkaline or neutral solution we write: $CO_3^{2-}(aq) + H_2O(1) < ----> HCO_3^{-}(aq) + OH^{-}(aq)$ The carbonate ion will react with whatever species is around. If there is an abundance of hydrogen ions (acidic solution) a *hydrogen carbonate* ion, or *bicarbonate* ion is formed. If there is not much hydrogen ion around, carbonate will steal a hydrogen ion from water, leaving a hydroxide ion behind and producing an alkaline solution.

There are two more reactions that further complicate the picture. First, if the solution is really acidic, the bicarbonate ion can also stick to a hydrogen ion and produce carbonic acid:

 $HCO_{3}(aq) + H^{+}(aq) < ----> H_{2}CO_{3}(aq)$

 $HCO_{3}(aq) + H_{2}O < ----> H_{2}CO_{3}(aq) + OH(aq)$

Carbonic acid can decompose into water and carbon dioxide gas:

 $H_2CO_3(aq) < ----> H_2O(l) + CO_2(g)$

This sequence of equilibria is also how beverages are carbonated, when water is pressurized under carbon dioxide gas, some of the gas dissolves and combined with water forms carbonic acid. Some of the carbonic acid splits into hydrogen ion and bicarbonate ion and the bicarbonate ion further splits into hydrogen ion and carbonate ion. All five species will be present but depending on the pH of the solution there will be more of one than another, keep it under pressure and it will stay 'carbonated'. Open it up and the CO₂ gets released as bubbly gas and the pH of the solution adjusts accordingly.

The sodium and potassium carbonate that is present in culinary ash is also used as a leavening agent in cakes, tortillas and breads. The purer that this can be made, the better it works and the less grit it leaves behind. Wood ash is a complex mixture of all the nonflammable, non-volatile minerals which remain after the wood and charcoal have been burned away, the presence of carbon dioxide in the hot fire gases has converted many of these minerals to their carbonate form. Most ashes consist of predominately sodium and potassium carbonate, sodium and potassium chloride, silica, and calcium carbonate. Adding ashes to water allows the water-soluble potassium and sodium salts to dissolve while the insoluble silica and calcium carbonate will settle to the bottom. Filtering the water and eliminating the solids gives us a fairly clear liquid of some concentration of chlorides and carbonates...To separate the chlorides from the carbonates, we will exploit the greater solubility of carbonates in hot water by bringing the liquid to a boil and continue boiling until enough water boils away for an insoluble precipitate to form. **Caution:** This solution is alkaline and caustic, as it boils along, it splashes--keep it covered, use gloves and goggles, this stuff will eat you. The precipitate is very likely a mixture of sodium and potassium chloride, and maybe some other chlorides and boiling is continued until half of the remaining water is removed, when we can be reasonably certain that only the soluble carbonates remain in solution. A brown coffee filter is your friend, pour the hot solution through the filter and discard the solid chlorides. As the liquid cools to room temperature, the less soluble sodium carbonate will precipitate first leaving the more soluble potassium carbonate in solution, the sodium carbonate can be filtered out of the remaining solution and, when boiled to dryness, leaves behind fairly pure solid potassium carbonate or potash. It takes a lot of wood to make a little ash and a lot of ash to make a little potash. For the purposes of culinary ash, we are really ready for

use with both sodium and potassium carbonates present, so once the chlorides have been filtered, the remaining solution can be used. We know that it is alkaline, but we don't know how alkaline, a pH reading would be nice, in the absence of a pH meter, the solution can be boiled until the water is gone and the remaining precipitate is relatively pure sodium and potassium carbonate in some unknown ratio but that is your culinary ash primary constituent, you can leaven grain products with it, there just needs to be some acidic elements present in the rest of the material. Sodium carbonate is sold as washing soda, soda ash and soda. You can buy washing soda in some grocery stores, on the laundry detergent aisle, next to the borax. It is used to remove calcium from hard water by forming an insoluble precipitate of calcium carbonate. Sodium bicarbonate is a much milder alkali than sodium carbonate, is sold as baking soda, or sodium hydrogen carbonate. It is used in baking, as the name suggests, and is a common ingredient in antacid tablets. You can buy baking soda in the grocery store on the baking goods aisle. In the presence of acids, it gives off carbon dioxide, which makes bread and cake nice and fluffy.

Traditional culinary ash was made from plants that were relevant to the people using them, the Navajo have a long tradition of using Juniper wood for culinary ash, they burn it really hot and preserve the lighter ash components, the smokey flavor that it can impart is part of its charm, in this author's opinion, and that gets lost when we wash it and filter it. There are several references to the use of beanstalk ash in maize dishes in the ethnohistories of the people of the Eastern Woodlands, specifically as either a preventative treatment or remedy for various diseases, including intestinal worms. The association between maize, ash, and health is also apparent in the social nature of the hominy foodway, which is the Eastern Woodland variation on nixtamalization. Alkali processed corn, hominy, has been regarded as a sacred, ancestral food and still has importance as a sick food, and a ceremonial dish. According to du Pratz: "When the natives are sick they eat no fish and very little meat, and they even abstain from that entirely if the nature of the malady demands it. Then they take only hominy or meal cooked in meat broth.^{2.5}" We also see this association on a social level in the *Pishofa* Ceremony practiced by the Chickasaw and Choctaw. While *pishofa* (hominy prepared with meat) is not used as a food to nourish the patient, it is the primary dish prepared and eaten by the attending doctor, friends, and family who maintain a multi-day vigil, providing rally and support for the patient. Perhaps because of its strong associations with the home, or perhaps simply because it was such a prolific dish, hominy was also broadly recognized as a hospitality food, one served to any and all visitors.

Hominy was the principal nixtamalization foodway among Native groups in the Eastern Woodlands, serving as the dietary backbone throughout the region, with nixtamalizing steps perpetuated even after the common bean was widely adopted. To explore this perseverance, we look at the social and cultural importance of the foodway, beginning with the conservative emotional attachments granted to the culinary tastes of native foodways that placed a premium on bitter, sour, even tart items, especially those that included lye and wood ash. It is not only a comfort food, but also a special occasion dish, not only a hospitality food, but a feasting food, one served to family, to friends, and

to strangers alike. Thanks to this social element, even when nixtamalization was no longer a critical nutritional practice, the activities and ingredients associated with it were inseparable from the larger cultural and social role the foodway played.

Culinary ash will chemically accomplish what the lime does for corn during Meso-American nixtamalization, and one study looked at information on the chemical composition, functional properties, sensory quality and protein value of tortillas made from the nixtamalization of maize using either lime or culinary ash. The Ca⁺, K⁺, Mg⁺, Fe⁺, and Zn⁺ content of lime and wood ashes showed lime to be higher in Ca⁺ content while wood ash contained more K⁺ and about 71% of the Ca⁺ content of lime. Both contained relatively high levels of Mg⁺, Fe⁺ and Zn⁺, but more so in the wood ashes. The level of reagent for nixtamalization was set at 0.8% of the maize weight. All other processing conditions were kept constant. The pH of the cooking solution was 12.0 for lime and 10.9 for wood ash. The moisture content of maize at 60 min of cooking was 45.8% for both treatments, however after 12 h of soaking, moisture level was 51.0% for the lime treatment and only 46.8% for the ash treatment. Solids (2.4%) in the lime cooking liquor were higher than in the wood ash liquor (1.0%). Chemical composition changes were similar between treatments in masa and tortilla; however, both masa and tortillas absorbed relatively high levels of all minerals including Fe⁺ and Zn⁺ from the wood ash treatment. The different treatment influenced functional properties particularly hardness and color. Tortilla characteristics were also similar. Protein quality of both alkali cooked products was lower than that of raw corn, more so the product from the wood ash treatment. Although some differences were observed in the sensory studies, human subjects did not dislike the wood ash made tortillas.

Hominy, in one form or another, and nixtamalization of one kind or another, was done by several native peoples across the Americas, for the Eastern Woodlands of North America, the people developed a technique that looks a lot like the Meso-American approach. First, dried flint maize kernels are soaked, usually overnight but for at least several hours, in a solution made from either hardwood ashes themselves, or the water collected after leaching through the ashes, essentially a Na⁺, K⁺ and OH⁻ (lye) solution. The kernels are ready when their hulls are either noticeably loosened or when the kernels begin to change color, turning either light yellow or white, then the kernels are processed by any combination of rinsing, rubbing, or grinding to remove the hulls as well as any excess lye or wood ash, then the kernels are boiled in an earthenware pot, for one to ten hours. Dishes fitting the general nixtamalizing description for hominy are referenced frequently in ethnohistoric sources for the Eastern Woodlands. Such references that describe processes for boiled maize, hulled maize, maize porridge, samp, sagamité, and other maize dishes described as boiled with ash or lye but not named. Of course, while there are considerable similarities, there are distinct, signature differences that identify various group traditions. The foundation includes the basic steps of nixtamalization that enable the transformation of maize into a nutritionally complete dietary staple, this is some relatively complicated chemistry and it makes one wonder if there was a more ancient tradition of processing corn that became culturally disseminated into successive generations or if people were teaching one another how to do this thing during times of

famine. It is interesting when humans pick up or develop a novel technology and how quickly good ideas spread through populations. A lot of Europeans died from pellagra when the conquistadors brought corn back to their homeland, they understood that corn was food but they didn't share the cultural knowledge of how to process it into a sustainable, nutritionally complete food.

Vinegar (French vvn egre-sour wine) is a sour liquid which is produced from the fermentation of diluted alcohol products, its key ingredient is acetic acid, which can range from 5% to 18%. Vinegar is as old as alcohol production and that makes it as old as civilization itself. Sumerian tablets from 5000 BCE describe using vinegar as a cleaning agent, as a condiment and as a food preservative, we find vinegar in Egyptian urns from 3000 BCE. Hippocrates spoke of using rue, thyme, pennyroyal, and lavender in aromatic vinegar applications. Dioscórides wrote of using brine vinegar infused with Creten thyme, barley groats, rue, and pennyroyal for driving out thick black humors. Known as "poor man's wine" (posca) in ancient times, vinegar was carried all over the world by Roman legionnaires. Medieval physician Saladin Ferro suggested using a mixture of rosewater and an aromatic acetum for washing the nose and faces of people who had the plague in his treatise Concilium de Peste written in 1448. He also suggested sprinkling it around the room. This was later simplified into an acetum containing roses, rue, and wormwood⁴. It has a long history of being used in many cultures as a condiment and preservative. Vinegar can be made from any fermentable or fermented liquid, including malted barley, rice, and cider; however, as its name suggests, it was probably first made from wine. It is not difficult to make, the easiest and most satisfying method to begin with is mixing an unpasteurized vinegar like Bragg's apple cider vinegar, or another vinegar starter culture, with some red wine and water. Any wine will work, It is easy to start with a cheap store bought red wine and use the water to dilute the alcohol to between 5%-9%. It is far more gratifying to ferment your own wine---and maybe some of it gets made into vinegar. Place the diluted wine in a jar and add around 25 percent of that volume of raw vinegar (if you have a liter of dilute wine, you are adding 250 ml of raw vinegar). Once mixed with the diluted wine, the Acetobacter will transform the alcohol into acetic acid. You need oxygen to make vinegar, so cover the jar with cheese cloth, a paper towel or light towel and then secure it with a rubber band or string for protection. A layer of primordial swamp-thing material, the vinegar mother, will form on top of the liquid within 3 to 4 weeks. Once the mother is about 1/2 inch thick, about 4-6 weeks, your vinegar is ready to go, strain the material through some cheesecloth and bottle it up. This approach is a confidence builder, because it is pretty bulletproof. You can take your next starter from this batch and keep the colony going in perpetuity. If you don't have a mother of vinegar after 4 to 6 weeks, something went wrong. There are a number of reasons why it could fail: The culture in the original raw vinegar wasn't alive, the temperature was too cold or too hot, you forgot to dilute the wine, you aren't living right, whatever... Toss it and try again with a new raw vinegar.

Vinegar can also be made fresh and from scratch with a double fermentation, in the first fermentation, yeast breaks down the sugars in the absence of oxygen producing alcohol and carbon dioxide, you are making a weak wine. In the second stage, the addition of oxygen enables *Acetobacter* to convert alcohol to acetic acid and that produces your vinegar...the important distinction is that alcohol is produced in an anaerobic environment and then vinegar in an aerobic environment. Over the centuries and around the world, a wide variety of vinegars has been created, with their own colors and flavors. These are used for culinary (pickling processes, vinaigrettes, salad dressing, condiments), medicinal, agricultural, horticultural, and cleaning purposes. High-quality vinegars, such as the balsamic vinegars prepared in Modena, Italy, continue to be produced via a slow process of fermentation, typically aging for years in wood barrels.

When we talk about medicinal uses of vinegars, the historical uses were both topical and internal, and we have to discuss the role that pH plays in extracting certain medicinal constituents from plants, and especially alkaloids. Alkaloids are alkaline, cyclic organic compounds containing nitrogen in their ring structure. While many alkaloids are classified according to their molecular skeletons, classification based on botanical origins is also common. They are generally water soluble under acidic conditions and lipid soluble under neural and basic conditions. This is especially important to remember--they dissolve in solution when protonated (acidic) and permeate biological membranes when alkaline, or deprotonated. Alkaloids are primarily derived from amino acids resulting in a wide variety of chemical structures, they can be found in about 20% of plant species and their production, extraction and processing remain significant economic centers for research and development, consider the economic importance of the alkaloids nicotine, caffeine, cocaine and heroin. Alkaloid production pathways have been manipulated genetically through natural and artificial selection of the plants that contain them for millennia in order to achieve higher production levels of alkaloids, much of what early humans learned about selective agriculture was through attempting to maximize alkaloid production in different plant species. In 1819, the German chemist Carl Meissner was the first to describe the active principles of these plants as alkaline in character and elucidated an extraction technique. Atropine from Atropa belladona, and hyoscyamine from Hyoscyamus niger were originally extracted in the early 1830's followed by scopolamine. The use of the coca plant, *Erythroxylum coca*, as a stimulant can also be traced to prehistoric times. Cocaine, the principal tropane alkaloid of Erythroxylon coca was first isolated in 1860. Alkaloid extraction and purification became central to the ethnopharmacological tradition and represents the beginning of medicinal chemistry. Therapeutically, alkaloids are particularly well known as anesthetics, cardioprotective, and anti-inflammatory agents. Well-known alkaloids used in clinical settings include morphine, strychnine, quinine, ephedrine, and nicotine. Contemporary medicine utilizes tons of atropine and scopolamine extracted from genetically modified cultivars, while ever growing demand enhances new, chemical and biotechnological methods of their manufacturing. In parallel, cocaine obtained from two Erythroxylon species, which is of limited use in medicine because of very strong addictive properties, became a subject of illicit manufacturing and trafficking of "recreational drugs", with socioeconomic and health endangering consequences on a global scale.

Vinegar is, in many ways, an ideal extraction solvent for many alkaloid containing medicinal plants. The term "acetract" is often used to describe the products of this type of extraction and is often most effective when the vinegar extraction is done alongside an alcohol extraction. I have been wildcrafting *Datura* for 30 years in the desert southwest, largely from the same location. The plant material is very consistent from year to year and I have tested what I have made with both thin-layer chromatography and HPLC. I don't need a lot; my clinic will use about a liter of tincture in a year. We collect it in October or November, trimming peripheral leaves and stems from numerous plants, often side by side with wild burros, we need 200 gms of dried material per liter of finished product, which is about two large brown paper grocery bags of fresh material. I like to freeze-dry the freshly collected and washed plant material, leaves and stems and the occasional flower, avoiding seeds and seedpods. I do a 1:5 dilution in a 65% Ethanol/1% Acetic acid solution (made by the liter by adding 200 ml of a 5% acetic acid apple cider vinegar to 800 ml of 82% Ethanol (or, 684 ml of 95% Ethanol, 200 ml apple cider vinegar and 116 ml water). I then let it sit in the dark for several weeks in a sealed 1gallon glass jug, agitating it when I think about it. When I have the time and I am alchemically inspired, the incubation will be 42 days, beginning at a new moon and ending at a full moon, then burning the marc and adding the ash back to the preparation (this changes the pH-for better or worse, you get to decide). Adding 1% glycerin at the end of the extraction mellows that high alcohol burn and makes the preparation more tolerable. So, what have we made? A dreadful poison and a powerful medicine, the leaves of Datura have a variable alkaloid concentration, it is generally highest right when the earliest thornapples are splitting and releasing their seeds...recognizing that this is a temperature and moisture-dependent phenomena, and so is alkaloid production. Dried leaf material at its peak will have 0.9-1.0 mg/gm of atropine (some variable racemic mixture of hyoscyamines) and 0.33 mg/gm scopolamine. We are using 200 gms of this material to make each liter of tincture which will yield 0.18-0.20 mg/ml atropine and 0.066 mg/ml scopolamine.

Corydalis rhizoma, known as *Yanhusuo* and used as a therapeutic agent in Traditional Chinese Medicine (TCM), is prepared from the dried tuber of *Corydalis yanhusuo* and is reported to have the functions of activating blood, moving "Qi" (vital energy) and relieving pain. It is used clinically as a botanical medicine for the treatment of pain (especially heart pain), amenorrhea and dysmenorrhea, postpartum stasis and obstruction. The chemical constituents of Yanhusuo have been isolated and identified as tertiary and quaternary alkaloids, many of these alkaloids, like tetrahydropalmatine, exert their effect by interfering with neurotransmitters in the central nervous system, others have shown anti-tumor activity, anti-inflammatory and analgesic activity, hepatoprotective effects, and antimalarial activity. Prior to their usage in clinics, crude drugs are subjected to traditional Chinese processing techniques (PaoZhi) such as cleaning, cutting and stir-baking with various other botanicals. Only processed slices of *Corydalis* are used for decoctions in clinics and as raw material for pharmaceutical manufacturing. There are four methods of preparation for Corydalis Rhizoma⁵, namely dry-, vinegar-, wine- and salt-frying, and studies have pointed out that there are large differences in the alkaloid content between the processed products. As first documented in Lei's Treatise on Processing of Drugs (Leigong PaoZhi Lun) in the Tang Dynasty of China (618–907 AD)⁶, Corydalis Rhizoma has been used mainly in vinegar and wine processed form. The preparation deepens the external color of the tubers and is believed to promote blood activation and pain relief. The difference between vinegar and wine processing is given by the processing adjuvants, yellow wine and rice vinegar, respectively. The function of yellow wine is to improve the pain relief effect, while rice vinegar increases the efficacy of the herbal drug⁷. Previous reports showed that vinegar processing can improve the analgesic effect of Yanhusuo and can also change the pharmacokinetics of the main alkaloids^{8,9}. With regard to the associated changes in composition, only a few of the main compounds of Yanhusuo have been studied. For example, vinegar processing was shown to cause an increase in tetrahydropalmatine and a decrease in berberine and protopine⁹.

Some alkaloids are better presented in an alkaline solution, Betel nut or betel quid chewing is an ancient human practice that involves chewing a mixture of areca nuts together with slaked lime (CaOH) and betel leaves to achieve a physiologically euphoric and stimulant effect. The practice is widespread throughout the world today but most common in Asia, Polynesia and Sub-Saharan Africa. The oldest evidence of its use is found in a burial pit in the Duyong Cave site of the Philippines, dating to around 4,600 years ago. Its diffusion is closely tied to the Neolithic expansion of the Austronesian peoples, spreading through the Indo-Pacific during prehistoric times, reaching Micronesia, Southern India, and Oceania 3500 years ago. It usually includes other substances for flavoring and to freshen the breath, like coconut, dates, sugar, menthol, saffron, cloves, aniseed, and cardamom. The areca nut itself can be replaced with or chewed with tobacco, and the betel leaves can be excluded altogether or traded for *Mitrogyna* leaves. The juice of the quid is not swallowed but spit out and tends to turn the gums and teeth a bright red color.

Betel quid is used by as many as 600 million people in Asia and is the fourth most widely used addictive substance in the world, after alcohol, caffeine, and nicotine. Yet, it remains the most widely used and understudied substance of abuse in the modern world. The components of the preparation, that is, the areca nuts, betel leaves and lime all hold ancient positions in the culinary and medicinal landscape of the cultures of Asia. *Piper* betle, commonly known as betel vine belongs to the family Piperaceae and is a popular and ancient medicinal plant in Asia. The leaf is the most widely used and studied part of the betel vine and it has a long history of use for oral health, it is rich in terpenes and broadly anti-microbial and is beneficial for reducing bad breath, strengthening the gums, preserving the teeth, and stimulating the digestive system. In traditional medicine practices, betel leaves are also used for vaginal douching, as a gargle/mouthwash and treatment for dental problems, headaches, arthritis, and joint pain. The boiled leaves are used as an astringent lung tonic, reducing cough from atonic, swollen tissue. A very large number of traditional applications of betel leaves are related to its antibacterial and antifungal properties. Areca catechu is originally native to the Malaysian peninsula, but its use has resulted in a long history of cultivation and naturalization throughout South

and Southeast Asia. It requires a warm, humid, tropical climate to thrive and seeds are the only means of propagation. The seeds have been widely used in traditional Chinese medicine as an antiparasitic agent for thousands of years and both leaves and seeds are used for the treatment of diarrhea, sunstroke, throat inflammations, edema, lumbago, bronchial catarrh, and urinary disorders. The areca seed is often called a nut in the marketplace, but it is more a berry than it is a nut, it is commercially available in dried, cured, and fresh forms. When the husk of the fresh fruit is green, the nut inside is soft enough to be cut with a typical knife. In the ripe fruit, the husk becomes yellow or orange, and as it dries, the fruit inside hardens to a wood-like consistency. At that stage, the areca nut can only be sliced using a special scissor-like cutter that is made for the purpose. The major alkaloids in betel nut are arecoline, arecaidine, guvacine, isoguvacine, and guvacoline. Arecaidine and guvacine are each hydrolyzed from arecoline and guvacoline, respectively, and the relative concentrations of the alkaloids change with the age of the plant, and the age of the seeds, total alkaloid content can range from 2.86-9.91 mg/gm dry weight¹⁰. Tannins present in betel nut are mainly proanthocyanidins along with catechins and arecatannin. The alkaloids are muscarinic receptor agonists, with some nicotinic acid receptor activity exhibited by arecoline and GABA uptake inhibition from arecaidine. This very ancient and ritualized activity involving the simultaneous consumption of two plants and a mineral that is used regularly by 20% of the world's population is a complex arrangement of psychotropic constituents. It is a decent anti-parasitic, with particularly good effect on tapeworm infestations, the mechanism of action is as a paralytic, the same mechanism as the organophosphate insecticides, overstimulation of acetylcholine receptors. Which can also cause the whole cholinergic cascade in humans, mostly it doesn't, each constituent adjusts and modifies the effects of the others so that the cascade is blunted, distorted and transformed. In interesting and subtle ways, people are using this agent to surf across their acetylcholine receptors and alter their perception of the world in a predictable and addictive manner, extracting drops of euphoria through washes of physiologic response. The long and the short of the process boils down to a stimulating effect on the mind, increased salivation, diarrhea, and watering eyes. Studies show that consumption of the betel nut quid improves recovery time from ethanol consumption, with a notably shortened duration of ethanol's vestibular effects, it has been shown to improve cognitive function and memory in dementia and Alzheimer's patients and reverses scopolamineinduced memory loss and learning impairment¹¹.

The pendulum swings to the extremes as it pertains to how our body responds to shifting pH, yet, our physiology is hardwired to hold our internal milieu to a pH range of 7.0-7.4. Through an intricate network of weak acid and base buffering systems into the active work of our kidneys and lungs, we do a pretty amazing job of maintaining that neutral pH. As we introduce certain items into the body, we affect this pH buffering system, and with a little forethought, we can improve our therapeutic interventions. A salt water wash through a neti-pot can be gloriously effective at reducing sinus congestion, adding a pinch of baking soda allows that wash to also neutralize histamines and recondition the lining of the sinus passageway. A hypersal nebulizer solution can be very

helpful for ling congestion, adding a little baking soda will render the secretions of the lung easier to move and less sticky.

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